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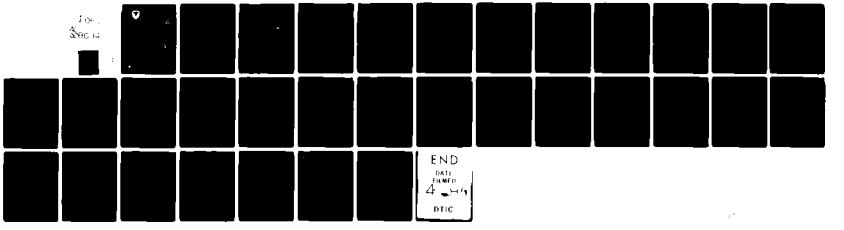

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HANDBOOK

FOR EVALUATING ECOLOGICAL EFFECTS OF POLLUTION AT DARCOM INSTALLATIONS

VOLUME 3

SPECIFIC EFFECTS OF POLLUTANTS IN SPECIFIC ENVIRONMENTS

DECEMBER 1979

U.S. ARMY DUGWAY PROVING GROUND
Dugway, Utah 84022

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Volume 3 of seven volumes dealing with evaluating ecological effects of pollution at DARCOM installations.

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pollution monitoring
ecology
terrestrial ecosystems
aquatic ecosystems
information systems
environmental fate modeling
military activities

20. ABSTRACT *(Continue on reverse side if necessary and identify by block number)*

This handbook provides the DARCOM commander with a tool whereby he can respond quickly to a potential or actual pollution incident with a decisive program to evaluate the ecological effects of the pollution. To implement the procedures as set forth in the handbook, the commander will enlist the help of an environmental team composed of DARCOM scientists (or other suitable personnel) and individuals with limited ecological training (paraecologists) who will do much of the manual labor. With a given volume, the team can perform the required functions. (con't)

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Item 20 (con't)

The handbook covers the following areas in seven volumes of which this is Volume 3: (1) basic questions that need answering, (2) conducting the preliminary investigation of the problem, (3) determining the specific effects of a pollutant (the first three volumes are essentially library efforts), (4) terrestrial sampling, (5) aquatic sampling, (6) unexpected declines in animal populations and (7) handling data.

TABLE OF CONTENTS

CONCEPT

Before the sampling program is designed, it is prudent to model the fate of the pollutant in the environment for the following reasons: (1) to suggest the best indicator organisms and the best way to sample those organisms, (2) to ensure the most efficient placement of sampling stations and (3) to establish a schedule of sampling best suited for evaluating the environmental effects of the pollutant. The model can be a simple, verbal model such as, "The pollutant has a high potential for bioaccumulation in plants (plant uptake and concentration above ambient levels)" or be a complex, mathematical model such as those referenced below.

Although the following quotation applies to the laboratory techniques for obtaining toxicity data, the conditions covered are no less important when attempting to model the fate of the pollutant in the environment.

"The toxicity of a material is a property of that material, and can only be described by its effects upon a living organism. As a general principle, toxic materials are toxic to all living things, while the individual susceptibility of each species to the toxic material varies, as do the susceptibilities of the individual members within a species. Within a species, susceptibility varies with age, sex, state of health, rate of dosage, diet, etc. Therefore, toxicity data, to be useful, must include all the above and must be stated in terms of the specific test animal or organism used, the routes of administration of the toxic matter, and the time of exposure. Also a sufficient number of test animals or organisms must have been tested to rule out some of the variables listed above and to make the data statistically significant."[1]

The first effort to identify data needs (Phase II, Volume 1) will undoubtedly identify data gaps that must be filled in order to model the specific effects of the pollutants in the specific environment of the installation. Consequently, as part of the first installation visit effort, (phase III, Volume 1) a literature survey will be conducted by the paraecologist under the general guidance of the environmental scientist. This survey will search the literature for information which could fill the above-mentioned data gaps.

[1]Quoted from Robert Herrich in Dangerous Properties of Industrial Materials, Fourth Edition, Reinhold Publishing Corporation, 1975.

USE OF THIS VOLUME

Volume 3 is divided into two parts: (1) a checklist of specific effects of pollutants in specific environments and (2) selected sources of information for specific effects of pollutants in specific environments. The team leader will review the checklist to establish the information he must have on the pollutant for modeling. He will then compare the information obtained during the first and second data-gathering efforts with that identified from the checklist to locate data gaps. The paraecologist will attempt to fill these data gaps from the literature.

The paraecologist will first contact the local technical libraries for the initial information sources[1] listed in part 2. If they are available, the paraecologist will research these sources for the required information. He will copy the pages containing the desired information, as well as the pages explaining the use of the source. If the information is not available from these sources, computer bibliographic searches will be conducted. These searches can be conducted through most large university libraries which have computer terminals. The paraecologist will discuss these data gaps with the science reference librarian, who will use this information to establish the keywords, concepts, subject terms or other conditions of the search. The printout resulting from the search will list references that might contain the required information.

Once all printouts are received, the environmental scientists will select the pertinent citations and give these references to the paraecologist, who will go to the library and obtain copies. Some references may have to be obtained through interlibrary loan. When the references have been obtained, the paraecologist can search the references for the required information. He will relay the findings to the team leader.

[1]If current editions of the references are required but are not available, the ecology team at Dugway Proving Ground, Dugway, UT 84022 or Chemical Systems Laboratory, Edgewood Area, Aberdeen Proving Ground, MD 21010 may be alternate sources.

FOREWORD

This volume was prepared by David A. Gauthier and Dr. Carlos F. A. Pinkham. The following people have contributed written material to Volume 3:

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Technical Library Staff, U.S. Army Dugway Proving Ground, Dugway, UT 84022.

NOTE

The pronoun "he" is used in this volume as an impersonal pronoun which encompasses he and she and has no intent of personal reference or connection.

NOTES

CHECKLIST OF SPECIFIC EFFECTS OF POLLUTANTS IN SPECIFIC ENVIRONMENTS

A. MEDIUM RECEIVING POLLUTANT

- Land
  - Surface
  - Subsurface
- Air
- Water
  - Surface
    - Freshwater
      - Lentic (lakes, ponds)
      - Lotic (streams, rivers)
    - Estuarine
    - Marine
      - Intertidal zone (shoreline)
      - Neritic zone (shoreline to edge of continental shelf)

B. POTENTIAL TOXICITY

- Man and other animals (Identify)
  - Toxic effects
    - Acute LD_{50}, LDLO, LC_{50}, LCLO, TD_{50}, TDLO (L, Lethal; D, dosage; 50, 50% of test organisms; LO, lowest response level; C, concentration; T, toxic, debilitating but not lethal)
      - Target organ(s)
      - System effect
      - Allergic or hypersensitive
    - Chronic LD_{50}, LDLO, LC_{50}, LCLO, TD_{50}, TDLO
      - Target organ(s)
      - Systemic effect
      - Allergic or hypersensitive
    - Special
      - Neoplastigenic (produces tumors)
      - Carcinogenic (produces malignant tumors)
      - Mutagenic (produces genetic changes expressed in the offspring)
      - Teratogenic (produces deformities during growth)
      - Behavioral
  - Routes of exposure
    - Hair, feathers, etc
    - Skin
    - Mucous membrane (including eyes)
    - Mouth

- Mechanisms of exposure
  - Ingestion
    - Grooming
    - Contaminated Food
    - Contaminated Water
  - Respiration
  - Absorption
- Factors affecting individual or species susceptibility
  - Age
    - Prenatal
    - Neonatal (newborn to one month old)
    - Juvenile
    - Adult
    - Aged
  - Sex
    - Male
    - Female
  - Condition
    - Nutritional
    - General health
    - Other stress
  - Habitat
    - Aerial
    - Terrestrial
    - Subterranean
    - Aquatic
    - Combination
  - Range
    - Sedentary
    - Local
    - Migratory
  - Other
    - Food habits
    - Distribution of race or subspecies
    - Seasonal variations (feeding, breeding, hibernation, etc)

- Plants
  - Toxic effects
    - Acute
      - Physical changes (visible changes; viz, death, stunted growth, chlorosis, etc)
      - Chemical changes (metabolic, other nutritional factors)
      - Genetic change (sterilization, decreased yield, delayed maturation, etc)
    - Chronic
      - Physical
      - Chemical
      - Genetic (more likely as chronic effect)

- Special
  - Neoplastigenic
  - Mutagenic
  - Teratogenic
- Routes of Exposure
  - Leaves
  - Roots
  - Bark
  - Other (aerial roots, flowers, etc)
- Mechanism of Exposure
  - Absorption (direct, indirect)
  - Respiration
- Factors affecting individual or species susceptibility
  - Age
  - Physical characteristics
    - Texture (smooth, hairy, rough, etc)
    - Growth requirements
    - Nutrient requirements (including water)
  - Biological characteristics
    - Reproduction rate and cycle
    - Life span and cycle (deciduous, evergreen, annual, perennial)
    - Adaptability to environmental change
  - Condition
    - Nutritional
    - General health
    - Other stress
  - Habitat
    - Aerial
    - Terrestrial
    - Aquatic
    - Combination
- Standards
  - Environmental Protection Agency (EPA)
  - Department of Transportation (DOT)
  - Occupational Safety and Health Act (USHA)
  - Department of the Army
  - State

C. COMBINATION OF SUBSTANCES INVOLVING THE POLLUTANT AS ONE MEMBER

- Other substances present (identify)
  - Identify interaction, if any (synergistic, additive)[1]
  - Toxicity of interaction
  - Known effects of interaction

[1] If the interaction produces a reactant different from either of the original substances, this reactant may be screened in the same manner as the original pollutant.

Target organs
Systemic effects
Magnitude of effects

D. METABOLISM OF POLLUTANT

Biomagnification (concentration of the pollutant within the food chain)

Identify food chain
Degree of biomagnification at each trophic level
Organisms in the food chain most susceptible to the toxic effects
Degree of susceptibility (see item B)

Bioaccumulation (concentration of the pollutant above ambient levels within an individual)[1]
Species which bioaccumulate the pollutant
Mechanisms of bioaccumulation
Levels of bioaccumulation above ambient concentration

E. DISPERSION/DIFFUSION MODELS[2]

Physical characteristics of source
Chemical composition
Molecular weight

[1]The term differs from that normally used which is "bioconcentration". However, the use of "concentration" in the standard definition of biomagnification and bioconcentration leads to confusion.

[2]Appropriate land subsurface models can be found in Metry, A.A., "The fate of pollutants in subsurface environments". Journal of Environmental Sciences, 20:27-31, 1977. This is an abiotic model (biological processes are not included).

Appropriate air (in air or deposition onto surfaces) models can be found in Cramer, H.E., et al, Development of Dosage Models and Concepts. U.S. Army Deseret Test Center Report DT6-TR-72-609, 1972. Available from DDC or H.E. Cramer Company, Inc., P.O. Box 8049, Salt Lake City, UT 84108. This is an abiotic model. Another source is U.S. Army, Construction Engineering Research Laboratory, Champaign, IL 61820. AIRMOD--A General Program for the Rapid Assessment of Airborne Pollutants, Welsh, R.L. and D.D. Webster, Feb 1978.

Appropriate biotic or abiotic water models can be obtained from U.S. Army Engineer Waterways Experiment Station, Environment Effects Laboratory, Vicksburg, MI 39180. They also can provide subsurface models. The Environmental Chemistry - Fate Modeling Section (E-35.21) of the American Society for Testing Materials, 1916 Rose St., Philadelphia, PA 19103 and The Office of Toxic Substances, 401 "M" St., S.W., Washington, DC 20460 are developing comprehensive water models.

- Specific gravity
- Normal atmospheric state (gas, liquid, solid)
- Density in vapor, liquid, and solid state
- Boiling, freezing, decomposition and flashpoint temperatures
- Vapor pressure and volatility
- Odor or appearance
- Solubility in water and in other liquids
- Viscocity
- Surface tension
- Size distribution of particles or droplets
- Rates of decay

Characteristics of Source Emission [1]

- Narrative description of source characteristics
- Geographical coordinates or map showing source locations
- Elevation above mean sea level
- Source dimensions (cross-sectional area, volume or stack diameter)
- Source height above ground level
- Total amount of material disseminated (source strength) or dissemination rate
- Concentration of material in soil solution
- Absorbed concentration of material
- Dissemination time (duration and time of day)
- Exit temperature, exit velocity, volumetric flow rate, average pore-water velocity

Receptor Parameters

- Narrative description of different receptors (flora and fauna) vulnerable to source emissions
- Geographical coordinates and distribution
- Elevation of receptors relative to source
- Toxicological values and physical response of receptors for various effects such as no damage or effects, mild damage or incapacitation, and lethal dose or dosage levels
- Breathing rate of mammals or description of population and activities performed
- Protection that may be available through low ventilation structures, etc
- Detoxification (time vs response) factors and population immunization levels
- Hydrodynamic dispersion coefficient
- Bulk density of dry soil
- Soil water content fraction

Meteorological Parameters

- Hourly surface weather observations to include:
  - Wind direction
  - Windspeed
  - Cloud cover

[1] The engineers responsible for the design of the operation are the best sources of this information.

- Cloud height
- Visibility and obstructions to vision
- Temperature
- Relative humidity
- Precipitation types and amounts

Meteorological data tabulations

- Wind direction occurrence frequencies
- Frequency and duration of persistent wind directions
- Windspeed occurrence frequencies
- Frequency and duration of persistent wind speeds
- Atmospheric turbulence measurements
    - Standard deviation of wind azimuths as a function of windspeed
    - Standard deviation of vertical wind angles as a function of windspeed
- Vertical profiles of temperature
- Height of surface mixing layer
- Cloud heights and cover by time of day
- Solar radiation
- Air temperature means and extremes
- Relative humidity means and extremes
- Precipitation type, frequency, amounts, rates and extremes

Site Characteristics

- Significant terrain features or topographical map
- Vegetative cover and characteristics
- Background atmospheric pollutants
- Watershed drainage patterns

Aquatic data for specific area

- pH
- Alkalinity
- Hardness
- Dissolved oxygen
- BOD (biochemical oxygen demand)
- Chlorides
- Sulfates
- Heavy metals
- Nutrients (carbon, nitrogen, phosphorus)
- Conductivity
- Suspended solids
- Cross-sections of body of water
- Flow regime
    - Flow rate through cross-sections of water
    - Tidal flow
    - Density of tidal water
    - Characteristics of salt wedge in estuary (leading edge of salt water flowing beneath lighter fresh water during flood tide)

Temperature variation through cross-section of water
Location of riffles, pools, backwaters, etc
Annual or seasonal trends in above categories

F. COMBUSTION AND DEGRADATION PRODUCTS

Receiving Medium (see item A above)
Conditions of receiving medium affecting combustion or degradation
Moisture content
Temperature
pH
Other reactants present (see item E above)
Sunlight
Oxygen level
Biological activities
Identify combustion and degradation products
Residence time (half-life) for pollutant and its combustion or degradation products
Information in items B through D above

(NOTES)

SELECTED SOURCES OF INFORMATION FOR SPECIFIC EFFECTS OF POLLUTANTS IN SPECIFIC ENVIRONMENTS

A. SELECTED BIBLIOGRAPHIC REFERENCES

(1) U.S. Department of Health, Education and Welfare, Public Health Service Center for Disease Control, National Institute for Occupational Safety and Health (NIOSH) Washington, DC. Registry of Toxic Effects of Chemical Substances, 6th ed., 1976.

The 1976 edition of the Registry of Toxic Effects, formerly known as the Toxic Substances List, has been prepared in compliance with the requirements of Section 20(a) (6) of the Occupational Safety and Health Act of 1970, Public Law 91-596, and includes the original list (1971) and all subsequent publications. This revision contains 82,908 lists of chemical substances, including 5,228 new chemical compounds not in the 1975 edition. The U.S. Department of Labor's Occupational Safety and Health Standards (OSHA); and data on carcinogenesis, mutagenesis, teratogenesis, human toxic effects, OSHA Standards and recommended standards from NIOSH Criteria Documents are included for many compounds.

The registry serves as a single source document for basic toxicity information as well as for such other data as chemical properties and information necessary for the preparation of safety directives and hazard evaluations for chemical substances for which standards have not been recommended or promulgated.

(2) Sax, N.I., Dangerous Properties of Industrial Materials, 4th ed., New York, Van Nostrand Reinhold Co., 1975.

A single source for quick, up-to-date, concise, hazard-analysis information on approximately 13,000 common industrial and laboratory materials. The hazard analyses include a toxic hazard rating or toxicology paragraph, a fire hazard rating; and explosion hazard rating and a disaster hazard rating, to give some idea of the hazards produced when quantities of a material become involved in disasters such as fire, explosion or flood.

(3) Tucker, R.K. and D.G. Crabtree, Handbook of Toxicity of Pesticides to Wildlife, Bureau of Sport Fisheries and Wildlife, Denver Wildlife Research Center, Resource Publication No. 84, 1970.

Although pesticides form a restricted family of compounds, they constitute a major source of potential problems on military installations. Furthermore, this reference is one of the few comprehensive documents with toxicity data on wildlife. The chemicals chosen are

ones to which wildlife are either often exposed or most susceptible. Most are widely used or represent common families of chemicals applied to forests, rangeland, aquatic habitats or agricultural areas. Acute toxicity data and a list of the common symptoms observed are presented for each pesticide. For some, particularly those likely to be applied repeatedly or to persist long after application, the results of 30-day repeated oral toxicity or feeding tests are also included.

(4) U.S. Fish and Wildlife Service, Washington, DC 20036. Lethal Dietary Toxicities of Environmental Pollutants to Birds, Hill, E.F., R.G. Heath, J.W. Spann and J.S. Williams, Special Scientific Report No. 191,1975.

This report is compilation and analysis of the results of nearly 10 years of testing the lethal dietary toxicities of pesticidal and industrial chemicals to young bobwhites, Japanese quail, ring-necked pheasants and mallards.

(5) Gosselin, R.E., H.E. Hodge, R.P. Smith and M.N. Gleason. Clinical Toxicology of Commercial Products, 4th ed., Baltimore: Williams and Wilkins, 1976

This book provides a list of trade-name products, together with their ingredients; addresses and telephone numbers of companies for use when descriptions of products are not available; sample formulas of many types of products, with an estimate of the toxicity of each formula; toxicological information, including an appraisal of toxicity of individual ingredients and recommendations for treatment and supportive care.

(6) Environmental Protection Agency (EPA) proposed regulation for Regulation of Discharge of Hazardous Substances into Waterways. The complete list, regulatory information and toxicity data, can be found in the January 9, 1976, issue of the Environment Reporter, Vol 6, No. 37

The proposed regulations (40CFR116) would designate 306 substances as hazardous and would limit their discharge under Section 311 of the Federal Water Pollution Control Act (40FR59959, December 30, 1975). These proposed regulations also establish categories of hazard and define penalties for discharge.

(7) Chemical Rubber Company (CRC) Handbook of Chemistry and Physics Cleveland, OH, 1977.

An excellent general source for chemical and physical data on inorganic and organic compounds. New editions are published annually.

(8) Office of Toxic Substances, Environmental Protection Agency, Washington, DC 20460. Identification Systems for Selecting Chemicals or Chemical Classes as Candidates for Evaluation, I.E. Flinn, T.J. Thomas and M.D. Bishop, Nov 1974.

Appendix E of this reference provides an excellent annotated listing of chemical information centers and systems. Appendix D provides a useful discussion of systems that can be used to identify or assess the hazard associated with chemicals.

B. SELECTED COMPUTER BIBLIOGRAPHIC SEARCHES

These searches are available at most universities at a minimal cost through computer retrieval services. Most searches can be obtained through three retrieval systems: DIALOG, ORBIT and MEDLARS, which together cover approximately 70 data bases, which in turn give access to thousands of journals, reports, conferences and books containing millions of articles. The most useful data bases of these retrieval systems are shown in Table 1 and described below. The printed references can include abstracts or descriptors, depending on the specific data base. The team leader is responsible for determining the specific data bases to be accessed.

The above data bases cover unclassified documents. In most cases they will provide the necessary information. However, if a search for classified documents is indicated, the Defense Documentation Center (DDC), Cameron Station, Alexandria, VA 22314 is the best source. It also lists unclassified DOD documents.

Table 1. Information on Computer Data Bases

File Name	Subject	Starting Dates	Update Frequency	File Size[a]	Abstract
AGRICOLA (NAL/CAIN)[b,c]	Agricultural	1970	Monthly	1,000,000	No
APTIC[b]	Air Pollution	1966	Monthly	81,500	Yes
ASFA[b]	Aquatic Science	1975	Monthly	7,000	No
BIOSIS[b,c]	Biology	1972	Monthly	1,330,000	No
CAB ABS[b]	Agriculture	1972	Monthly	425,000	No
CANCERLINE[d]	Cancer	1963	Monthly	37,000	Yes
CANCERPROJ[d]	Cancer	1975	Monthly	16,000	Yes
CIS INDEX[c]	Legislation	1970	Monthly	12,000	Yes
CHEMCON[b]/CHEM 7071[c]	Chemistry	1970	Bimonthly	2,330,000	No
COMP DISS ABS[b,c]	Comprehensive	1861	Monthly	580,000	No
ENERGYLINE[c]	Energy/Environment	1970	Bimonthly	34,000	No
ENVIROLINE[b]	Environment	1971	Bimonthly	65,000	Yes
GEOREF[c]	Geology	1967	Monthly	360,000	No
MEDLINE[d]	Medicine	1966	Monthly	731,066	Yes
METEOR/GEO ABS[b]	Meteorology	1972	Irregular	27,000	No

(continued)

Table 1. Information on Computer Data Bases

File Name	Subject	Starting Dates	Update Frequency	File Size[a]	Abstract
NTIS[b,c]	Technology	1964	Biweekly	600,000	No
OCEANIC[b]	Oceanography	1964	Bimonthly	98,000	No
POLLUTION[b,c]	Pollution	1970	Bimonthly	48,000	No
SSIE[c]	Comprehensive	1974	Monthly	324,000	Yes
TOXLINE[d]	Toxicology	1971	Monthly	320,000	Yes
USDA CRIS[b]	Agriculture	1974	Monthly	28,000	Yes

[a]Approximate number of citations (concluded)

[b]DIALOG data base

[c]ORBIT data base

[d]MEDLARS data base

On-line and off-line searches result in the same information. On-line searches provide the references immediately but are more expensive and may be limited in the number of references printed; off-line searches are inexpensive, unlimited in the number of references cited and are mailed to the requestor within a few days. The choice of which search to use will be the responsibility of the team leader, based on the urgency of the situation.

File Descriptions:

AGRICOLA (NAL/CAIN)

CAIN is the cataloging and indexing data base of the National Agricultural Library (NAL). This massive file provides comprehensive coverage of worldwide journal and monographic literature on agricultural and related subjects.

APTIC

APTIC is a computerization of Air Pollution Abstracts covering all aspects of air pollution, its effects, prevention and control.

ASFA

Aquatic Sciences and Fisheries Abstract is a comprehensive data base on life sciences of the seas and inland waters, as well as related legal, political and social topics.

BIOSIS

BIOSIS contains world wide citations from both BIOLOGICAL ABSTRACTS and BIORESEARCH INDEX. BIOLOGICAL ABSTRACTS includes accounts of original research from nearly 8,000 primary journal and monograph titles. BIORESEARCH INDEX includes additional citations from symposia, reviews, preliminary reports, semipopular journals, selected institutional and government reports, research communications, and other secondary sources.

CAB ABS

A comprehensive file of agricultural information containing all records in 22 journals published by the Commonwealth Agricultural Bureaux, Great Britain

CANCERLINE

CANCERLINE is the National Cancer Institute's on-line data base dealing with cancer therapy and chemical, physical and viral

carcinogenesis. References are obtained from Cancer Therapy Abstracts and Carcinogenesis Abstracts.

CANCERPROJ

The CANCERPROJ data base contains summaries of on-going cancer research projects being conducted by cancer scientists in many countries. The data for the project descriptions are processed by the Current Cancer Research Projects Analysis Center (CCRESPAC) of the International Cancer Research Data Bank (ICRDB) Program. This center is at the Smithsonian Science Information Exchange (SSIE) in Washington, D.C.

CIS INDEX

The Congressional Information Service Index covers publications emanating from the work of committees and subcommittees of the U.S. Congress: hearings, reports, committee prints, and other documents. Public laws are added annually. Cross-disciplinary coverage includes public services programs, raw materials and consumer products, industry technology, legal questions, national and international government policies and events, conservation and the full range of issues and topics of legislative concern.

CHEMCON/CHEM 7071

This is the computer-readable file corresponding to the printed Chemical Abstracts. It provides access to the world's scientific and technical literature for chemistry, chemical engineering, and chemical aspects of the life sciences. Coverage includes journal articles, patent specifications, reviews, technical reports, monographs, conference proceedings, symposia, dissertations and books.

COMP DISS ABS

Comprehensive Dissertation Abstracts is a subject, title, and author guide to virtually every American dissertation accepted at an accredited institution since 1861, when academic doctoral degrees were first granted in the United States. In addition, it disseminates citations for thousands of Canadian dissertations and an increasing number of papers accepted in institutions abroad.

ENERGYLINE

ENERGYLINE is the computerized data base from Energy Abstracts and Energy Index. It screens over 2,000 journals and research reports, surveys, hearings, irregular serials, monographs, and conference proceedings to provide comprehensive coverage of some 20 different energy-related areas.

ENVIROLINE

ENVIROLINE covers the world's environmental information as found in Environmental Abstracts and Environmental Index. Its comprehensive interdisciplinary approach provides indexing and abstracting coverage of more than 5,000 international primary and secondary source publications reporting on all aspects of the environment. Literature covered includes periodicals, government documents, industry reports, proceedings of meetings, newspaper articles, films and monographs. Also included are rulings from the Federal Register.

GEOREF

GEOREF provides primary coverage of the geological journals. About 25 percent of the sources are nonserial documents, such as books, separately authored chapters in monographs, government documents, conference proceedings, and theses. Subject coverage includes some 29 different geoscience areas.

MEDLINE

MEDLINE is an on-line bibliographic search service designed by the National Library of Medicine to provide health professionals with rapid access to current literature. It is the computerized data base corresponding to Index Medicus, Index to Dental Literature and International Nursing Index.

METOR/GEO ABS

Meteorological and Geoastrophysical Abstracts provides citations in English for the most important meteorological and geoastrophysical research published in both foreign and domestic literature. Citations are taken from approximately 200 primary sources, including technical journals, monographs in series, proceedings, reviews, and annual publications.

NTIS

The National Technical Information Service data base consists of government-sponsored research, development and engineering reports, plus analyses prepared by federal agencies, their contractors or grantees. It is restricted to unclassified, publicly available, unlimited distribution reports. State and local government agencies are now beginning to contribute their reports to the file.

OCEANIC

Oceanic Abstracts organizes and indexes worldwide technical literature on the seas of the world. It is designed to help researchers

find out about published materials on many marine-related subjects.

POLLUTION

Pollution Abstracts is a leading resource for references to environmentally related literature on pollution, its sources and its control.

SSIE

The Smithsonian Science Information Exchange covers research in progress and recently completed research sponsored by over 1,300 federal, state and local government agencies; associations and foundations; individual investigators; universities and colleges; and some industrial and non-U.S. organizations. It includes basic and applied research in all areas of the life, physical, social, behavioral, and engineering sciences.

TOXLINE

Toxicology Information, On-Line is the National Library of Medicine's extensive collection of computerized toxicology information, containing references to published human and animal toxicity studies, effects of environmental chemicals and pollutants, adverse drug reactions and analytical methodology.

USDA CRIS

USDA CRIS is a current-awareness file for agriculturally related research projects produced by the USDA cooperative state research service.

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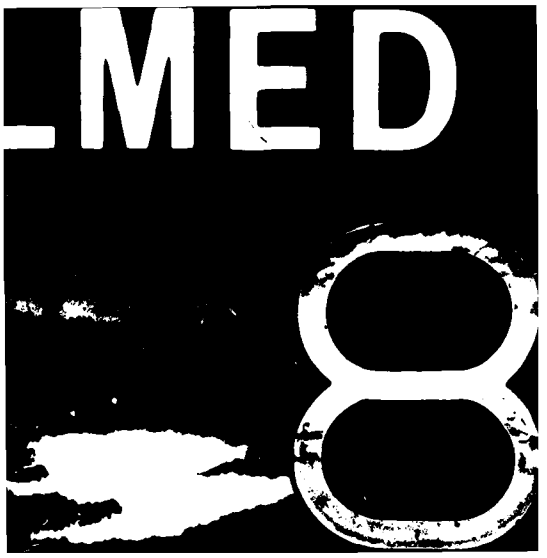
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